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# Maintenance management and lean manufacturing practices in a firm which produces dairy products

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### Abstract

While enterprises are struggling to go on existing in the intensive competitive environment, unexpected breakdowns occur at unexpected times, thereby leading to the emergence of halts in production and to hitches in production plans. As a result, enterprises suffer from the loss of revenue as they fail to hit the production quantity that they have aimed at. The fact that the maintenance plans have been made well is an important issue in the prevention of the losses due to breakdowns within an enterprise. This gains more importance particularly when the production system grows and the production quantity increases. It is necessary to plan the activities to be carried out to ensure that the machines and plants of enterprises are working continuously. All management activities concerning the practices including such issues as the determination of maintenance priorities as well as preparation and supervision of maintenance plans are carried out with maintenance management. This study described the implementation of maintenance management and lean manufacturing techniques at the maintenance workshop in order to eliminate the losses due to breakdowns and to enhance productivity and the motivation of employees at an enterprise which produced dairy products.

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### 1.Introduction

The increasing of the production quantity and product diversity and the enhancement of productivity and the competitive power under the market conditions which are getting harder are among the basic objectives of enterprises today. Many management systems have occurred recently, when such concepts as productivity, quality, and cost have

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gained importance. One of these systems is maintenance management, which is efficiently used to prevent the losses resulting from the breakdowns within an enterprise. Enterprises make great investments in machinery and equipment and naturally want to get the returns from their investments concerned. The halting of machines and plants due to breakdowns or the fact that they work below the production capacity causes significant losses for an enterprise.

Delays and halts in production due to the breakdowns taking place during production for technical reasons can only be prevented by performing maintenance in a planned and scheduled way. The failure to carry out maintenance in a planned fashion affects the long-term objectives of enterprises and also costs enterprises a lot. Maintenance costs have a significant place in the total operating costs of enterprises. Mobley [2002] emphasized that the average maintenance costs in the food industry were about 15% of the cost of the food & drink produced.

Lean manufacturing is a concept which aims at sounder, more productive and more effective manufacturing by eliminating all elements of waste in the manufacturing process. Lean manufacturing aims to perform production with zero defects, to reduce costs, to meet customer requests at the moment and amount desired, to hold no excess inventories, and to continually make improvements by eliminating waste. 5S, a lean manufacturing technique, comprises 5 terms which help lean manufacturing and visual checks, define workplace practices, and are interrelated in terms of letter 'S'. Initially, the objectives of total productive maintenance (TPM) were to enhance the equipment performance, to reduce variability, and to shorten the period of supply. Later on, however, the enhancement of the total operating performance became the main objective of the TPM. Total productive maintenance includes the gradual improvement of quality; productive maintenance, cleaning, and order; new manufacturing technologies; and the harmonization of the equipment in advanced technology with employees.

First the literature review on maintenance, maintenance management, and lean manufacturing was described in this study. Later on, the maintenance management implemented at an enterprise which produced dairy products and the lean manufacturing activities at the maintenance workshop to carry out maintenance in a planned and controlled way, to perform production in time by minimizing the halts due to breakdowns, to reduce maintenance costs, and to eliminate waste were described. The purpose and results of the study were provided in the last section.

## **2. Literature Review**

Maintenance is defined as a whole of all technical actions taken to protect or preserve a part so that it can fulfill its necessary functions within the desired life cycle [Marquez, 2007]. Monks (1996) defined maintenance as the whole of activities designed to keep production tools and other entities at a state to support the goals of an enterprise in the best way. Heizer and Render (2012) emphasized that maintenance covered all procedures carried out to ensure that the equipment of the manufacturing or service system worked with the expected productivity and under the expected conditions.

Maintenance planning refers to the planning of the activities to be carried out to ensure that the machines and plants of a factory are working continuously.

### *2.1 Definition and Classification of Maintenance Activities*

Maintenance systems cover all planned and unplanned activities which are carried out to increase the operation of an installed system to an acceptable level or to keep it at such a level at any production or service plant. The purposes of the maintenance activities carried out at enterprises are listed as follows [Bakım, 2013]:

- To reduce the production cost and to enhance yield and product quality;
- To ensure the continuity of production by reducing the halts in machines;
- To ensure the realization of the production programs to be prepared beforehand;

- To ensure the increasing of the capacity utilization rate;
- To extend the useful life of any plant, machine, and equipment and therefore ensure that a greater yield is obtained from the capital spent for these investments;
- To provide the security of the staff that uses any machine or equipment; and
- To reduce maintenance and repair costs.

An effective maintenance system should be set up in compliance with the specified management policies and technical specifications in order to ensure that the efficiency of the machine and equipment with which production is performed is at the desired level. It is expressed that maintenance costs might be at the rates of 5% to 40% among production costs but can rise up to around 70% in some sectors, although varying by enterprise (Bevilacqua and Braglia, 2000; Köksal, 2007).

Maintenance planning gains more significance particularly when the production system grows and the production quantity increases. Maintenance activities have a greater effect on the production flow especially at the enterprises which perform mass production [Tekin, 2003].

We can classify maintenance activities into two categories as planned maintenance and unplanned maintenance [Wireman, 2013].

#### *2.1.1 Unplanned Maintenance*

This method is implemented at the plants and workshops which perform production by means of the machines which have a large number of substitutes, which can be repaired easily, and which are not very expensive. Their maintenance and repair costs are low, and fewer employees are required.

#### *2.1.2 Planned Maintenance*

Many problems and breakdowns are determined during planned maintenance, and their improvement is fast and costs low through planned maintenance. To carry out planned maintenance work and in order for the results to be as good as desired, each part of a machine must absolutely be under control. The advantages provided by planned maintenance can be listed as follows:

- It minimizes halts and reduces possible breakdowns and the production cost;
- It provides the realization of the production programs prepared beforehand as well as safe working;
- It increases the yield of an enterprise and reduces energy expenses;
- It helps with the extension of the machine life;
- It minimizes the inventories of materials and spare parts; and
- It reduces the requirement for employees.

We can subdivide planned maintenance into three subgroups as a) periodic maintenance; b) predictive maintenance; and c) preventive maintenance:

##### *2.1.2.1 Periodic Maintenance*

Periodic maintenance is a type of planned maintenance which aims to extend the equipment life and to reduce unplanned halts and which is performed for the factory and the equipment. In this method, occurrence of breakdowns is not expected and possible breakdowns are prevented as a result of the maintenance of the system which has earlier been done periodically.

### *2.1.2.2 Predictive Maintenance*

It is the whole of efforts to quantify the trends of the physical parameters of the equipment, to compare them with the known engineering limits, to analyze and interpret the results, and to make the problems likely to cause breakdowns ineffective and correct them economically [Topaz and Sümen, 2003].

### *2.1.2.3 Preventive Maintenance*

Preventive maintenance does not aim to reveal the breakdowns of machines but to prevent the occurrence of a breakdown at the beginning. This method entails performing considerable research and development activities in the lubrication, design, and engineering services for the nonoccurrence of a breakdown. For such reasons, the use of this method at small-sized enterprises is limited; however, it is employed more commonly than in the large-sized enterprises with R&D departments.

## *2.2. The Computerized Maintenance System*

The aim of using the computerized maintenance system is to quantify maintenance efficiency and maintenance support. The computer programs regarding special equipment may include availability, reliability, and sustainability; the duration of a halt or a breakdown; the average period between breakdowns; the average duration of a breakdown; the average duration of a repair; the breakdown time; statistical studies like the Weibull analysis; and the measurements about planned and unplanned maintenance management [Dhillon, B.S, 2002].

## *2.3. Lean Manufacturing in Maintenance Planning*

### *2.3.1. What is lean manufacturing?*

Lean manufacturing is a concept which aims at sounder, more productive and more effective production by eliminating all elements of waste in the manufacturing process. For further information, see [George, 2004].

Womack et al. (2007) defined lean manufacturing as a system which aimed to perform production with minimum manpower, by using the minimum production area, by consuming minimum resources, by holding inventories at the minimum level, by making minimum defects, by producing products at the shortest time, and by minimizing customer dissatisfaction.

Elimination of the elements of waste is one of the most important elements to obtain the maximum outputs with the minimum inputs in all processes in the lean manufacturing process [Seth and Gupta, 2005].

Toyota specified the 7 types of waste for lean manufacturing as overproduction, inventory, transportation, defects, processing, motion, and waiting. Some techniques employed in the practices of the lean manufacturing system are Kaizen, 5S, total productive maintenance, Kanban, and Poke-Yoke.

5S, one of the lean manufacturing techniques and taking its name from the five Japanese words starting with ‘S’, is a lean manufacturing technique which envisages the organization of a working area as being clean, tidy, and in accordance with the targeted goal. These words are seiri=sort, seiton=order, seison=cleaning, seiketsu=standardization, and shitsuke=discipline (Salem et al., 2006; Hodge et al., 2011).

An increase in productivity, a decrease in waste, saving of time by doing the work faster, an increase in

occupational safety, a decrease in machine breakdowns, an increase in motivation and a decrease in the cost are among the advantages of 5S for producers. We can mention its advantages for customers as the improvement of the producer-customer relationship, acceleration of responses to requests, the meeting of increasing demands of customers, and an increase in quality. Furthermore, the advantages of 5S for employees include its creation of a more comfortable and safer working environment as well as the fact that it provides them with an opportunity of displaying their creativity, broadens their perspectives, enables them to manage themselves, and provides them with an opportunity of reviewing their habits [İstanbul Chamber of Industry, 2011].

Rather than being a specific lean manufacturing technique, Kaizen studies constitute an approach which encompasses any improvement made with all other techniques [Salem et al., 2006]. Kaizen is a Japanese term and a lean manufacturing technique which aims at better or continuous improvement [Moore, 2007].

### *2.3.2. Total Productive Maintenance in Lean Manufacturing*

It is seen that the studies performed on total productive maintenance (TPM) have particularly multiplied in the recent years. There are studies in relation to the understanding of TPM with applications particularly in the manufacturing sector and in different fields on various scales, particularly on the adaptation and yields of the applications to enterprises.

Miyake et al. (1995) examined the understandings and interrelationships of just-in-time production, total quality control, and total productive maintenance – the complementary practices in the development of manufacturing systems. They investigated what kinds of practices were made in thirty-seven establishments out of the enterprises which had been awarded the TPM award. McAdam and Duffner (1996) made examinations on how to perform the TPM practices more effectively at the companies where total quality programs were implemented. Chand and Shirvani (2000) explored the effects of total productive maintenance studies at an enterprise which performed cellular manufacturing and which qualified as a supplier of the automotive industry. They determined overall equipment efficiency and the losses due to six big losses. Kodali and Chandra (2001) modeled the requirements for the TPM by using the analytical hierarchy process (AHP) – one of the multivariate decision-making techniques. They stated that the specified priorities could be used in strategic and operational practices within the scope of the TPM.

In their study on examining the applications of TPM in the electronics industry, Chan et al. (2005) examined an enterprise which produced semi-conductive products. As a result of the applications of TPM, they stated that development had been achieved in the use of equipment. They determined that there had been an increase in the knowledge and skills of employees and that their desire to work had developed positively. Patra et al. (2005) examined an office TPM application in a library. In the study performed with the implementation of 5S, they stated that a more productive working environment had formed and that employee satisfaction had increased. Considering the practices in Belgium and the Netherlands, Pinjala et al. (2006) explored and compared different management and maintenance understandings such as advanced manufacturing technologies (AMT), just-in-time production (JIT), total productive maintenance, and outsourcing on the basis of the obtained data.

In their study, Rodrigues and Hatakeyama (2006) first of all touched upon the TPM success factors, then criticized cases like the failure of the top management to embrace the matter, and stated that the system should be adopted by all employees. Giyici (2007) implemented the total productive maintenance system at the enterprises in the manufacturing industry and stated that a profit was achieved in costs and that the breakdowns decreased.

In the most general sense, total productive maintenance (TPM) can be defined as “the productive maintenance in which the participation of all employees is envisaged and which takes place by means of small group activities. The TPM is an approach which requires the participation of all employees in production activities, which also provides operators with the responsibility for the autonomous maintenance of the machine or equipment on which they work,

which prevents breakdowns, and which aims to maximize equipment efficiency [Chaneski, 2002]. We can list the objectives of the TPM system as follows [Baralı et al., 2001]: to enhance workbench productivity, to increase the product quality, to reduce defects (Zero defects), to reduce losses (Zero losses), to reduce waste (Zero waste), to reduce inventories (Zero inventories), to reduce work accidents, to increase the maintenance quality, and to increase the ideas about improvement.

Total Productive Maintenance (TPM) is the combination of preventive maintenance activities and the philosophy of Total Quality Management in order to create a TPM culture by providing integration with maintenance, engineering, and management units in order to guarantee that employees protect the equipment and machinery they use and that machines work properly at every moment. The TPM is the whole of the teamwork-based activities company-wide in order to preserve quality in equipment and in processes accordingly and to ensure total equipment efficiency. The TPM is not a concept which is merely related to maintenance. It is also an important step of the understandings of Total Quality Management and Lean Manufacturing. It has focused on zeroing the losses likely to occur before, during, and after a process in order to keep the general working conditions of a machine or a process at the best level [Görener and Yenen, 2007].

### **3. Maintenance Management at an Enterprise which produces Dairy Products and Lean Manufacturing Practices at the Maintenance Workshop: A Case Study at Güneş Gıda San. ve Tic. Ltd. Şti.**

It was set up as a family company under the name ‘Güneş Süt Mamulleri Ltd. Şti.’ in Sakarya in 1964. Having entered the food sector by producing yogurt, the company went on existing by producing ayran and kaşar cheese after 1972. It underwent a restructuring process as ‘Güneş Süt Gıda San. Tic. Ltd. Şti.’ in 1995. Upon this action, the process of change commenced for the company. The brand name, which used to be Güneşoğlu, was changed into Güneş. The milk processing capacity of the company in the early years was 5 tons, whereas it has begun to increase it to 120 to 150 tons recently. The product diversity has been increased with the new production plant, and yogurt, ayran, white cheese, local cheeses, mozzarella, butter, lor cheese, cream and cream cheese are produced by using the state-of-the-art technology.

#### *3.1 Current State of Güneş Süt Gıda San. Tic. Ltd. Şti.*

##### *3.1.1. Current State of Maintenance Management*

The breakdowns occurring in production at the factory are notified by phone to the people responsible for maintenance by the employee who uses the workbench but not recorded in writing. Hitches in communication by phone occur due to the busy working conditions, and the unrecorded breakdowns may be forgotten. This leads to the extension of the durations of maintenance. Maintenance is performed only when there is a breakdown since no maintenance plans are available. This leads to the following results:

- Maintenance people are unable to answer their phones while working; therefore, the breakdowns are not immediately answered;
- When several problems are told at a time, maintenance people forget the breakdowns as no records are available;
- The inventories cannot be controlled as the eliminated breakdowns and the used parts are not recorded;
- The performance of the employees cannot be quantified as it is not known which employee has eliminated which breakdown;
- Breakdowns are continually occurring since no maintenance plan is available.

##### *3.1.2. Current State of the Shelf System at the Maintenance Workshop*

The current shelf systems are rather disorganized at ‘Güneş’ company, which complicates the access of employees



to the parts they will use while performing the maintenance. This leads to the loss of time, thereby causing delays in the durations of maintenance. Furthermore, the inventory quantities of the materials cannot be known either due to the disorganized state of the shelves. Thus, they lead to unnecessary orders of materials and cause the factory to suffer from financial loss.

The current state of the shelves at the maintenance workshop at the factory is seen in the following images.



Figure 1 (a),(b),(c). The Shelves at the Maintenance Workshop

### 3.2. The System recommended at Güneş Süt Ürünleri Ltd.Şti

#### 3.2.1. A transition to the computerized maintenance system

To perform the maintenance management still used at ‘Güneş’ company, a maintenance module was included in the Axapta program in the process of transition to the computerized maintenance system. Axapta or Microsoft Dynamics AX is some ERP software which was produced by Microsoft and belonged to the Microsoft Dynamics family. It has three modules regarding maintenance, namely the Maintenance Form, the Breakdown Request, and the Inventory Record. These modules and their use are described below.

**i. Breakdown Request:** When any workbench breaks down at an enterprise, the employee must fill in the breakdown request form. This form contains information on the requesting employee, date, hour, department, the name of the workbench, and the reason for the breakdown.

The breakdown request starts when employees fill in “the breakdown request form” and is transferred to the

department of maintenance planning. The maintenance department includes this incoming request in the program according to its state of urgency. In this way, the maintenance plan has been prepared by the maintenance department. According to this plan, the maintenance team will go to the unit where the breakdown has occurred in order to perform the repair and the maintenance and eliminate the breakdown.

**ii. Maintenance Form:** The date and hour of occurrence of the breakdown, information about which machine has been maintained at which department, the person who has performed the maintenance and the parts replaced during the maintenance are recorded in this form.

All breakdowns and maintenance actions are recorded by means of this form. When a breakdown occurs at the same workbench again, it is maintained without any loss of time as the maintenance carried out and the parts replaced previously are seen thanks to this record form. Since the dates of the maintenance performed are recorded, it is easier to monitor the performance of employees.

After the person responsible for the maintenance has eliminated the breakdown, he/she enters the date, the hours of commencement and termination, the department, the workbench, the type of maintenance, the reason for the breakdown, the parts maintained, and his/her name into the maintenance request form. The maintenance form is shown in Figure 2.

Tarih	Başlangıç Saati	Bitiş Zamanı	Ambar	Sabit Kıymetler	Bakım Tipi	Arıza Nedenleri	Bakımcılar	Bakımcılar
12.11.2014	09:00:00	10:30:00	000509	Lor Kayma Makinesi Kır-1500	Arıza Bakım	Malzeme	Ferdi Mal	
27.11.2014	09:00:00	10:00:00	000500	Gıranajlama Makinesi Kır-1500	Planlı Bakım	Makine	Furkan Güneş	
26.11.2014	09:00:00	17:00:00	000500		Hat Değişikliği	Diğer	Celil Demirel	
26.11.2014	09:00:00	17:00:00	000507	Ayrılan Dolum Makinesi	Arıza Bakım	Makine	H. Bulent Okuç	
30.11.2014	09:00:00	17:00:00	000509		Hat Değişikliği	Diğer	Celil Demirel	
30.11.2014	09:00:00	10:00:00	000501	Kağız Protezyt Kazanı	Arıza Bakım	Malzeme	Ferdi Mal	
1.12.2014	09:00:00	11:00:00	000402		Arıza Bakım	Diğer	Celil Demirel	
4.12.2014	17:00:00	17:00:00	000701		Arıza Bakım	Makine	Ferdi Mal	
10.11.2014	00:00:00	00:00:00	000100		Arıza Bakım	Makine	Ferdi Mal	
12.12.2014	09:30:00	10:00:00	000501	Kağız Tayma Arabası 40 Adet	Arıza Bakım	Operatör	Ferdi Mal	

Bakım Yapılan Parçalar:

- Valf ☐
- Zincir ☐
- Mali ☐
- Düğü ☐
- Yağlama ☐
- Kayıp ☐
- Bulama ☐
- Kaçak ☐
- Motor ☐
- Pistonlu ☐
- Redüktör ☐
- Redüktör ☒
- Düğü ☐
- Açıklama

Figure 2. Maintenance request form

### iii. The Inventory Record

The unnecessary orders placed used to cause extra costs as no inventory record was kept in the current state. To prevent this, an inventory record module is available below the maintenance module. After the required materials have been entered into the maintenance request form by the employees of the maintenance department, the quantities of the materials used are deducted from the inventory. Considering the inventory records, orders should be placed for the materials whose inventory level has decreased.

The transition to the computerized maintenance system at Güneş company. will provide such advantages as

- Saving of time as it provides ease of use;
- Making a detailed definition of every part of the important equipment at the enterprise;



- Standardization of methods, ways, and maintenance times;
- Effective tracking and checking of the periodic maintenance program;
- Providing an opportunity for an analysis of breakdowns and halts;
- Minimization of defects; and
- The ability of customers, sellers, business partners, and employees to make efficient interconnections with each other.

### 3.2.2. A Transition to the Shelf System at the Maintenance Workshop

The use of no shelf systems at enterprises leads to the loss of time and therefore the loss of materials due to the unavailability of any order. This disorganized state at the maintenance workshop causes extra workload for employees, thereby decreasing their motivation. This also leads to the failure to solve the breakdowns just in time and causes the factory to work with low productivity.

It was aimed to eliminate the above-mentioned disadvantages by using the methods of 5S and Kaizen out of the lean manufacturing techniques at the enterprise. In the 5S method, first the materials were classified and these classified materials were placed in some specific order. This order allows finding the materials easily and saving time. The continuity of this system was ensured by standardizing it. Such advantages as:

- Placing the material onto the shelves properly and recording them,
- Classifying and placing the materials according to appropriate shelf areas,
- Preserving the material on the shelves under appropriate conditions until it is needed,
- Finding the desired material on the shelves easily and finding and maintaining it without spending time, and
- Not placing unnecessary orders for materials as inventory records are kept

are obtained through the new shelf system used. The new shelf systems bought in order to be used at the enterprise are seen in Figure 3. These shelves were divided according to the sizes and numbers of the materials stored. The shelves were labeled to place each material, and the labels were stuck on the shelves. Later on, all materials were placed onto the labeled shelves. A map was prepared for the department where the shelves were located in order to enable the employees to easily access the material they searched for. The employees can easily find the products they want by means of this map, which reduces the losses of time. Hence, the durations of halts and costs resulting from breakdowns in production will decrease.



(a)



(b)

Figure 3(a), (b). The Workshop Shelf used after the Application

#### 4. Conclusion

Upon the rapid progress of technology and globalization today, the meeting of customers' requirements and expectations and even the desire to exceed the expectations further increase the competition among enterprises. The renewal and development of production systems and of the management ways of thinking have become indispensable requirements in the intensive competitive environment. Today, when customers' expectations are continually changing, enterprises have begun to employ new ways of management and new techniques in order to go on existing. One of these innovations takes place regarding maintenance activities.

The workbenches that enterprises use in production today have gradually begun to contain more advanced technologies. Accordingly, a more efficient understanding of maintenance than the traditional repair and maintenance activities is needed at enterprises. Therefore, maintenance management has become a crucial issue. Maintenance management, which enables one to perform maintenance more productively, is a management system which allows maintaining workbenches in a planned manner and according to rules, which organizes all employees, and which can support the whole production.

The increase in the competition among enterprises day by day brings the maintenance costs – one of the costs that enterprises can control – to the forefront. With good planning and scheduling, it is possible to save on maintenance costs and to ensure that the competitive power increases.

The process of transition to the computerized maintenance system within the scope of maintenance management and the implementation of lean manufacturing techniques at the maintenance workshop were described in this study. Lean manufacturing was implemented to ensure that by eliminating all elements of waste in the manufacturing process, production was sounder, more productive, and more effective with minimum manpower, by consuming minimum resources, and by keeping inventories at the minimum level. As a result of this study, it was aimed to provide the continuity of production by reducing the halts in machines, to reduce the production cost, to increase yield and the product quality, to realize the production programs to be prepared beforehand, to increase the capacity utilization rate, to extend the useful life of machinery and equipment, to ensure the safety of the staff, and to reduce maintenance and repair costs.

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